BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B69 12053

SUBJECT: Mars Mariner '71 Variable Surface Features Television Experiment: Preliminary Footprints for Selected Revolutions of the B Mission Orbit Case 235

DATE: December 16, 1969

FROM: G. A. Briggs

ABSTRACT

A preliminary study has been made of a photography mission plan for the variable surface features experiment of the Mars Mariner 1971 project. The imagery data is to be acquired from the MM '71 'B' mission orbit which has a period of about four-thirds of a Martian day.

The mission plan contained herein has been developed for the first 100 days of the orbital mission and detailed photography sequences have been considered at 25-day intervals. No attempt has been made to adjust the timing of the photography to coincide with multiples of the 82-second time centers of the spacecraft's Data Automation System.

A table showing how illumination, emission and phase angles vary over the 100 days considered is included in the information provided.

BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B69 12053

SUBJECT: Mars Mariner '71 Variable Surface Features Television Experiment: Preliminary Footprints for Selected Revolutions of the B Mission Orbit Case 235

DATE: December 16, 1969

FROM: G. A. Briggs

MEMORANDUM FOR FILE

INTRODUCTION

This memorandum contains details of a preliminary mission plan designed for the study of variable surface features from the Mars Mariner '71 B mission orbit. The proposed B mission orbit, Figure 1, has a 32.877 hour period, a 50° inclination and a periapsis located ∿5° on the day side of the evening terminator at the start of the mission.

Photography for variable surface features studies will take place in the region of the noon meridian because high illumination is preferred for the investigation of surface reflectivity changes. In order that this investigation be impeded as little as possible by the lack of knowledge of the surface photometric function, it is required that the changes in illumination and emission (or viewing) angles from revolution to revolution be minimized. A more detailed description of the requirements and problems of the variable surface features study is contained in a previous memorandum.(1)

Charts showing the ground trace of the orbiter on different revolutions and overlays showing viewing angle and illumination angle contours (all of which form part of Reference 1) were used extensively in developing the mission plan contained herein. The "footprints" of the photographs on the planet's surface were computed by an expanded version of the program used to calculate the above mentioned ground traces and contours.

PRELIMINARY VARIABLE SURFACE FEATURES MISSION PLAN

Figures 2-6 show the A camera (11° x 14° field of view) footprints of the proposed photography sequences for selected revolutions between Day 1 and Day 100. Every sixth pass of the spacecraft over one of the three regions observable at high sun (the orbital period is ∿4/3 of the Mars period of rotation) has been examined, i.e., every 18th revolution at ∿25-day intervals. Tables 1-5 contain detailed information about each sequence of photographs.

At the present time no attempt has been made to adjust the timing of the photography to coincide with multiples of the 82-second time centers of the Data Automation System. It is believed that such an adjustment could be made straightforwardly without significantly changing the features of the mission plan detailed here.

For Figures 2-6 the zero of the longitude scale has been arbitrarily chosen. The true anomaly θ of the spacecraft, the angle between the vector from the center of Mars to the spacecraft and the line of apsides as measured from periapsis in the direction of travel, is approximately 270° when the spacecraft passes through the noon meridian at the start of the mission. At this time the spacecraft's longitude ϕ is about 12°. The orbital period has been chosen so that every third revolution the spacecraft passes the noon meridian at this same Mars longitude in order to minimize changes in illumination angle.

At the start of the mission variable surface features photography commences at a true anomaly, θ, of 260°, about 1.1 hours before periapsis, and ends at θ = 294°, about 0.5 hours before periapsis. The order in which the pictures are acquired is indicated in the Figures by the alphabetic sequence A-I, the position of the letter indicating the surface intercept of the picture center. The planned slewing pattern of the scan platform during the sequence ("down" from the equatorial horizon to the sub-spacecraft region, back to the horizon and down a second time) has been designed to economize on the total angular slewing required. This is necessary because of the limited rate at which the platform pointing can be changed (0.25°/sec). Up to about Day 50 the coverage acquired by the variable surface features photography is of a region about 60° longitude x 50° latitude.

The seasonal motion of Mars about the sun has the effect of bringing periapsis further onto the day side of the planet as the mission evolves and after 100 days the variable surface features photography commences at a true anomaly of 280°, about 0.7 hours before periapsis. The sequence ends at θ = 319°, about 0.27 hours before periapsis. It is found empirically that, on the last revolution considered, illumination and viewing angle variations can be made smaller by adopting the different slewing pattern shown in Figure 6.

The average altitude of the spacecraft is much lower during the picture taking sequence at the end of 100 days than at the beginning of the mission. For this reason the surface resolution will be significantly improved and the coverage of each picture reduced accordingly. The overall coverage of the

whole sequence is also diminished considerably, particularly at the more southerly latitudes. This reduction is the result of the contraction of the spacecraft's horizon and of the shortening of the time available for variable surface features photography.

SCAN PLATFORM SLEW RATES

The limited rate at which the scan platform can be slewed, 0.25°/sec, imposes an important constraint on the acquisition of variable surface features imagery. The importance of the constraint stems from the fact that the scan platform may be rotated about only one of its two axes (clock and cone) at any time because of spacecraft power considerations. In addition, platform motion during the readout of the vidicon (41 sec) may not be permissible so that the complete time interval between successive exposures may not be available for platform motion.

In planning the photography sequences a check was therefore made to be sure that the proposed platform slews can in fact be achieved. Column 12 in Tables 1-5 shows the time interval between successive A camera exposures. Column 13 indicates the minimum slew rate necessary to reach the required platform pointing in the time available. This rate is equal to the sum of the clock and cone increments divided by the time interval minus 41 sec. It is required that the rate indicated in Column 13 be less than 0.25°/sec.

In the event that a narrow angle B camera (1.1° x 1.4° field of view) photograph is also required near the center of the preceding A picture, an AB pair would be acquired without intermediate platform slewing. The wait time before moving the platform would then be 82 sec so that the minimum required slew rate would be increased. Column 14 indicates the value of this rate; where this is greater than 0.25°/sec an AB pair cannot be obtained.

If it were desired to take two A pictures of the same surface region, e.g., for spectral studies, an even larger wait would be required, namely, 3 x 41 sec = 123 sec. Column 15 indicates the value of the minimum slew rate required to allow the acquisition of an AA pair. Again feasibility is demonstrated by a value of less than 0.25°/sec.

CHANGES IN ILLUMINATION, EMISSION AND PHASE ANGLES*

Table 6 contains the values of the illumination, emission and phase angles for nine selected points on the surface for the moment at which they are photographed on each of the five revolutions considered. The selected points are the centers of the nine photographs taken on the first revolution. Not all these points can be rephotographed later in the mission because of the manner in which the spacecraft-planet geometry changes.

Over the first 50 days the illumination angles change by between 2° and 7° and the emission angles change by between 1° and 5°. The changes that occur over the second 50 days are more variable because the geometry of the orbit relative to the region of interest is changing more rapidly. Illumination angle changes of as much as 17° and emission angle changes of as much as 9° are found to occur for the points considered. In general changes in phase angle are considerably greater than the changes in either of the other two angles. In one of the instances considered a change of over 30° is noted over 100 days.

SUMMARY

It may be concluded from this study that there are no major obstacles involved in the development of a photography mission plan for the variable surface features experiment. In the preliminary mission plan described herein, contiguous coverage of an area 60° longitude x 50° latitude can be acquired straightforwardly early in the mission. It is found that as the mission evolves the coverage of southern mid-latitudes diminishes appreciably but coverage of lower latitudes can be maintained.

The variations in illumination, emission and phase angles have been tabulated for various stages in the mission. A further study is required to determine what detection threshold for changes in the Martian surface albedo is implied by the various angular changes associated with this preliminary mission plan.

1011-GAB-caw

G. A. Briggs

Attachments

---

*Both illumination and emission (or viewing) angles are defined with reference to the local vertical. For vertical sun the illumination angle = 0°. The emission angle at the sub-spacecraft point is 0°.

REFERENCE

(1) "Illumination and Viewing Conditions Encountered by the 1971 Mars Mariner TV Experiment," G. A. Briggs, Memorandum for File, October 31, 1969.

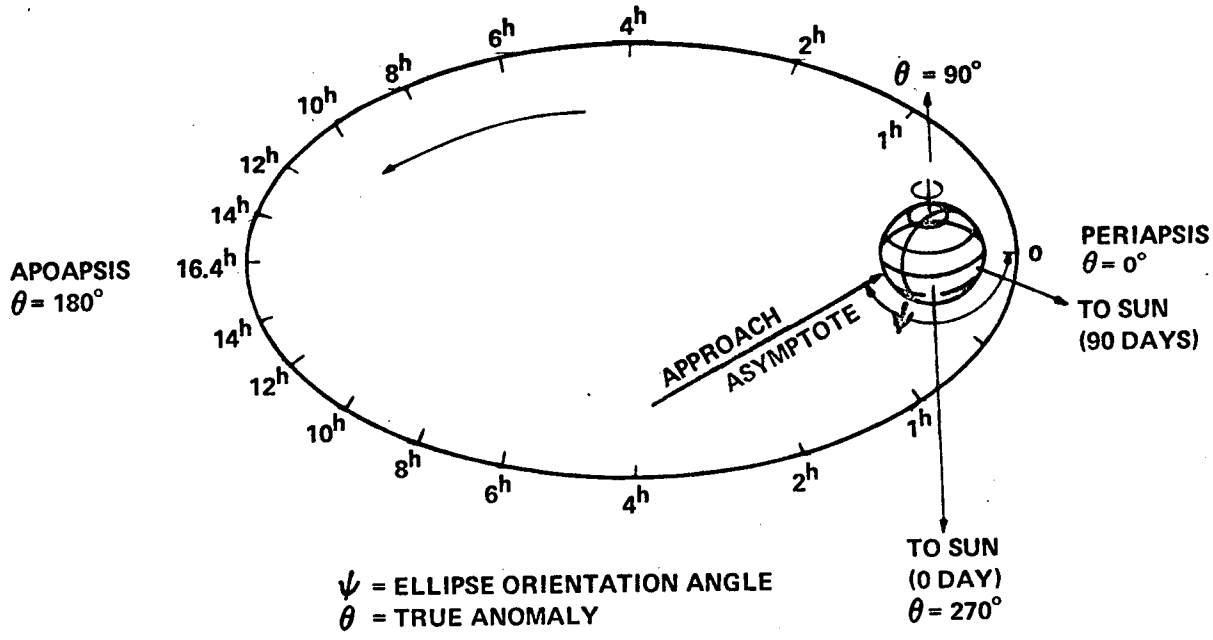

FIGURE 1. B MISSION ORBIT FOR VARIABLE FEATURES STUDIES, PERIOD = 32.877 HOUR, INCLINATION = 50°, ψ = 155°

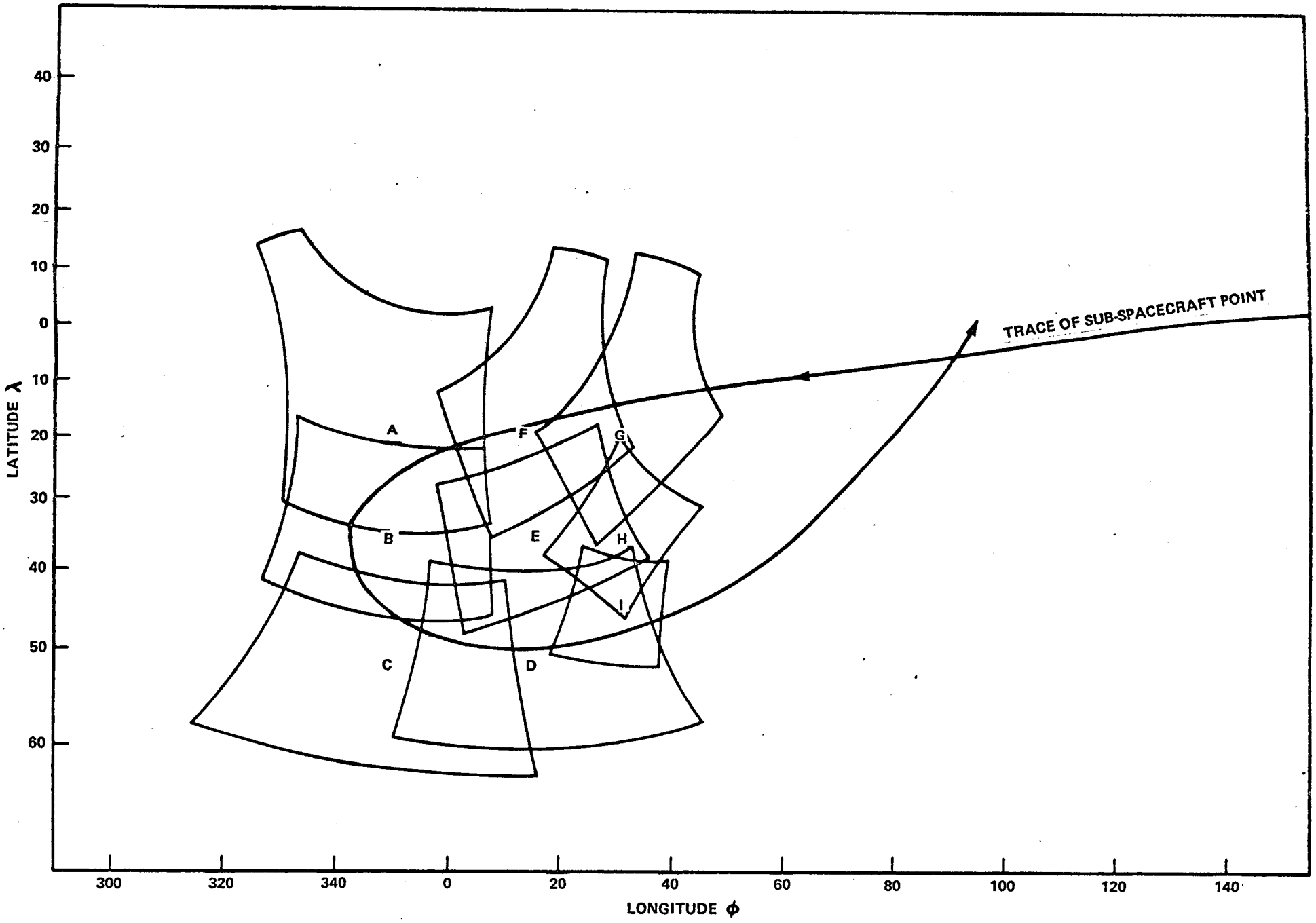

FIGURE 2. VARIABLE SURFACE FEATURES PHOTOGRAPHY SEQUENCE ,REVOLUTION 1, DAY 1

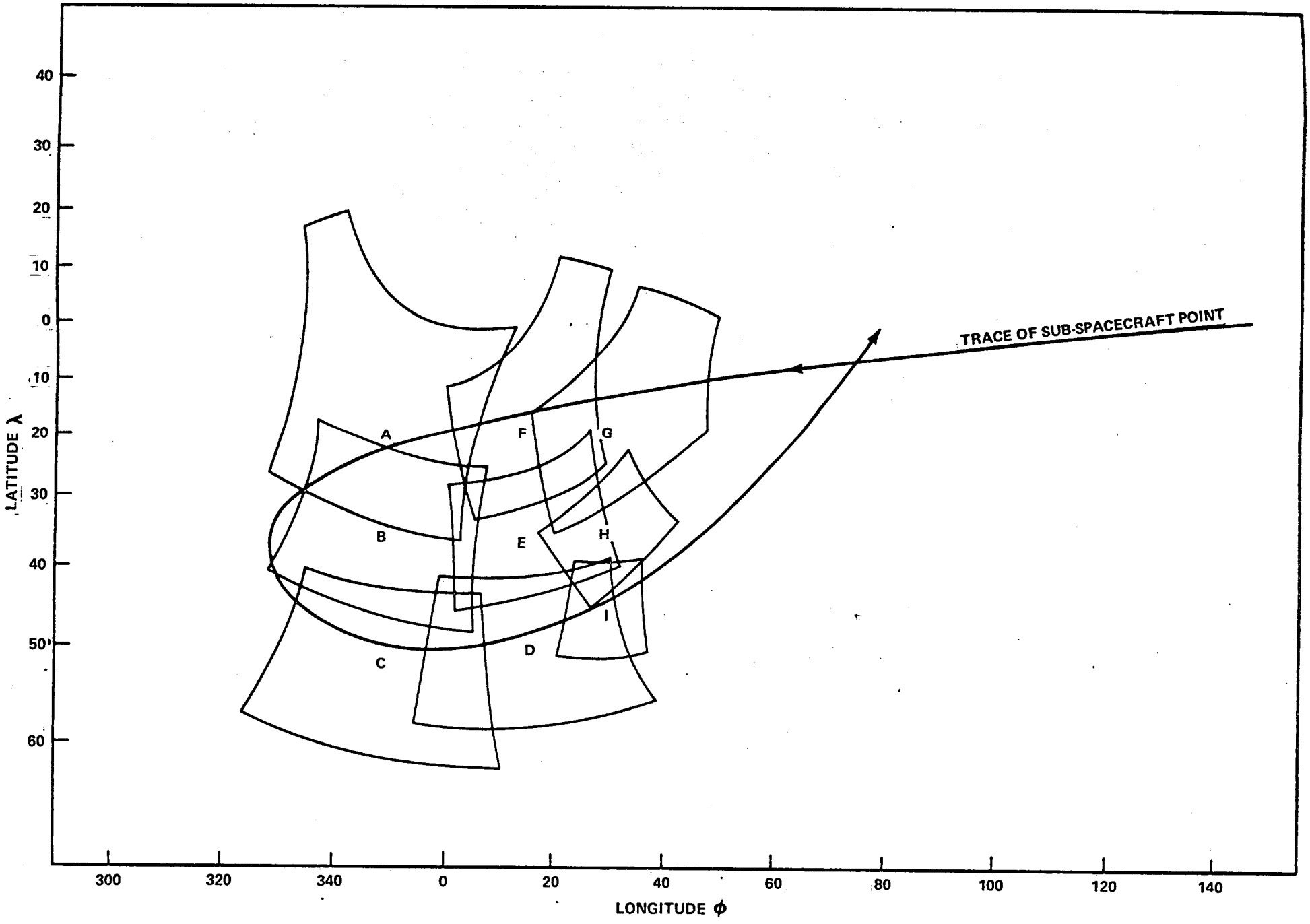

FIGURE 3. VARIABLE SURFACE FEATURES PHOTOGRAPHY SEQUENCE ,REVOLUTION 19, DAY 26

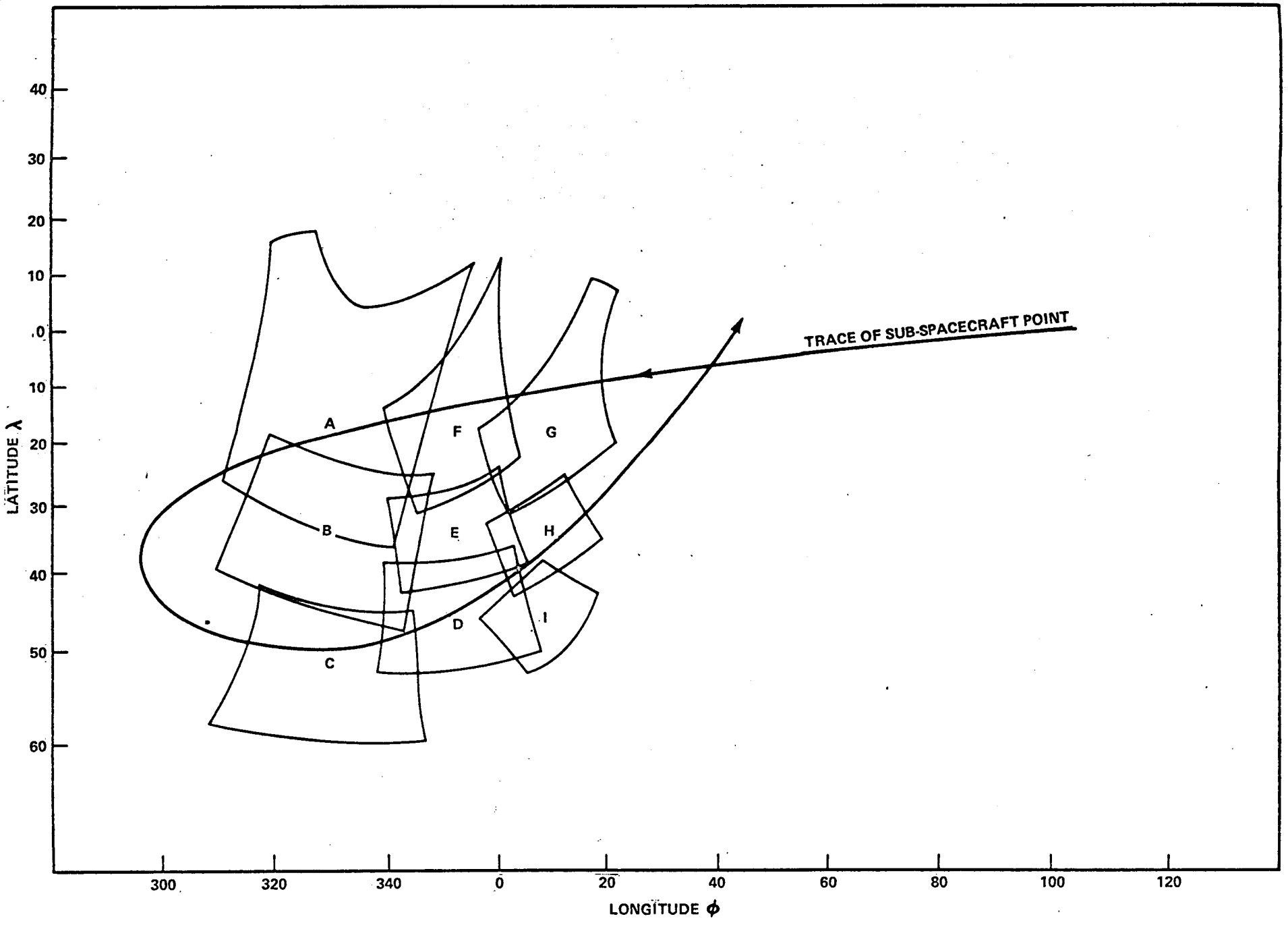

FIGURE 4. VARIABLE SURFACE FEATURES PHOTOGRAPHY SEQUENCE ,REVOLUTION 37, DAY 51

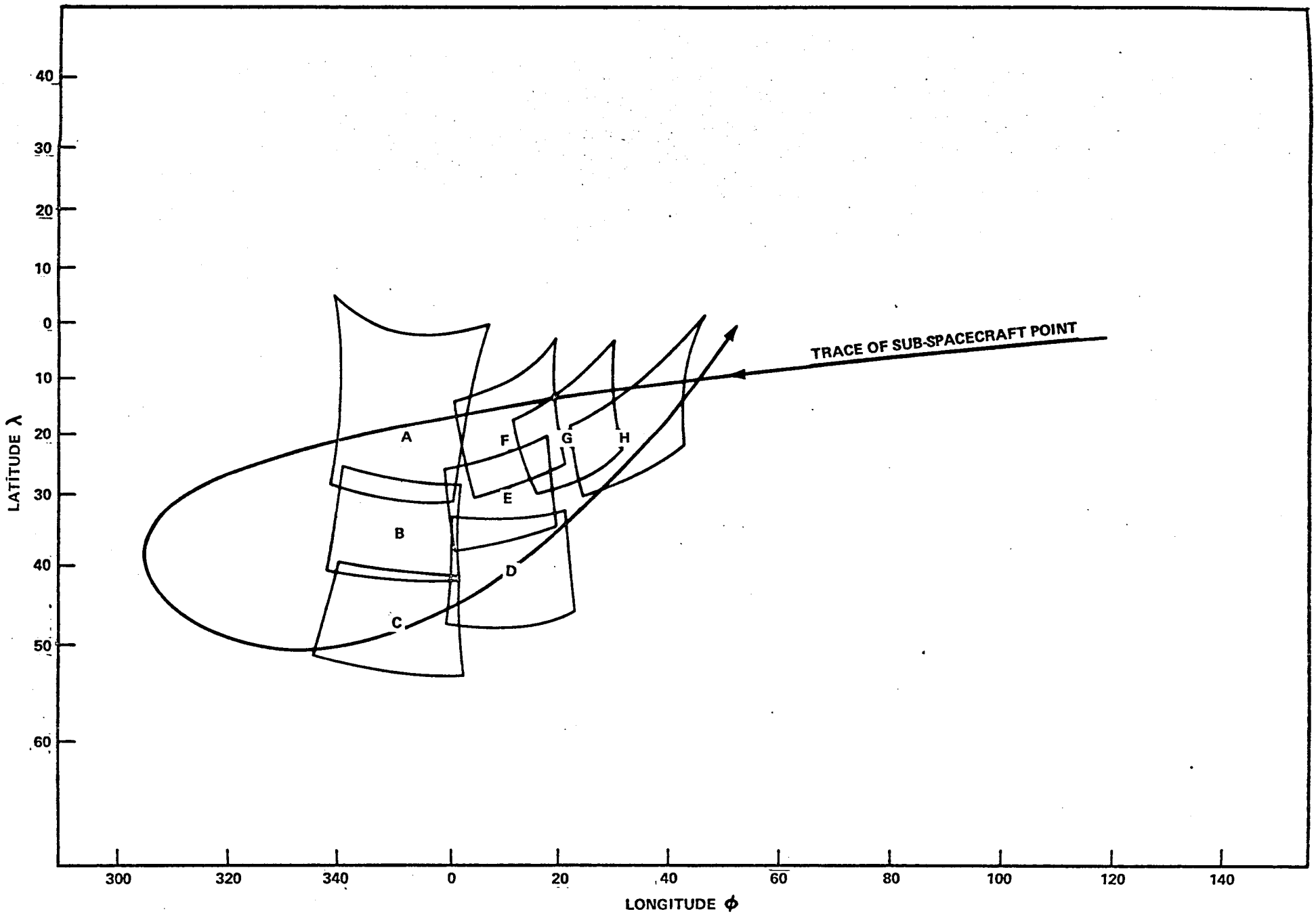

FIGURE 5. VARIABLE SURFACE FEATURES PHOTOGRAPHY SEQUENCE ,REVOLUTION 55, DAY 75

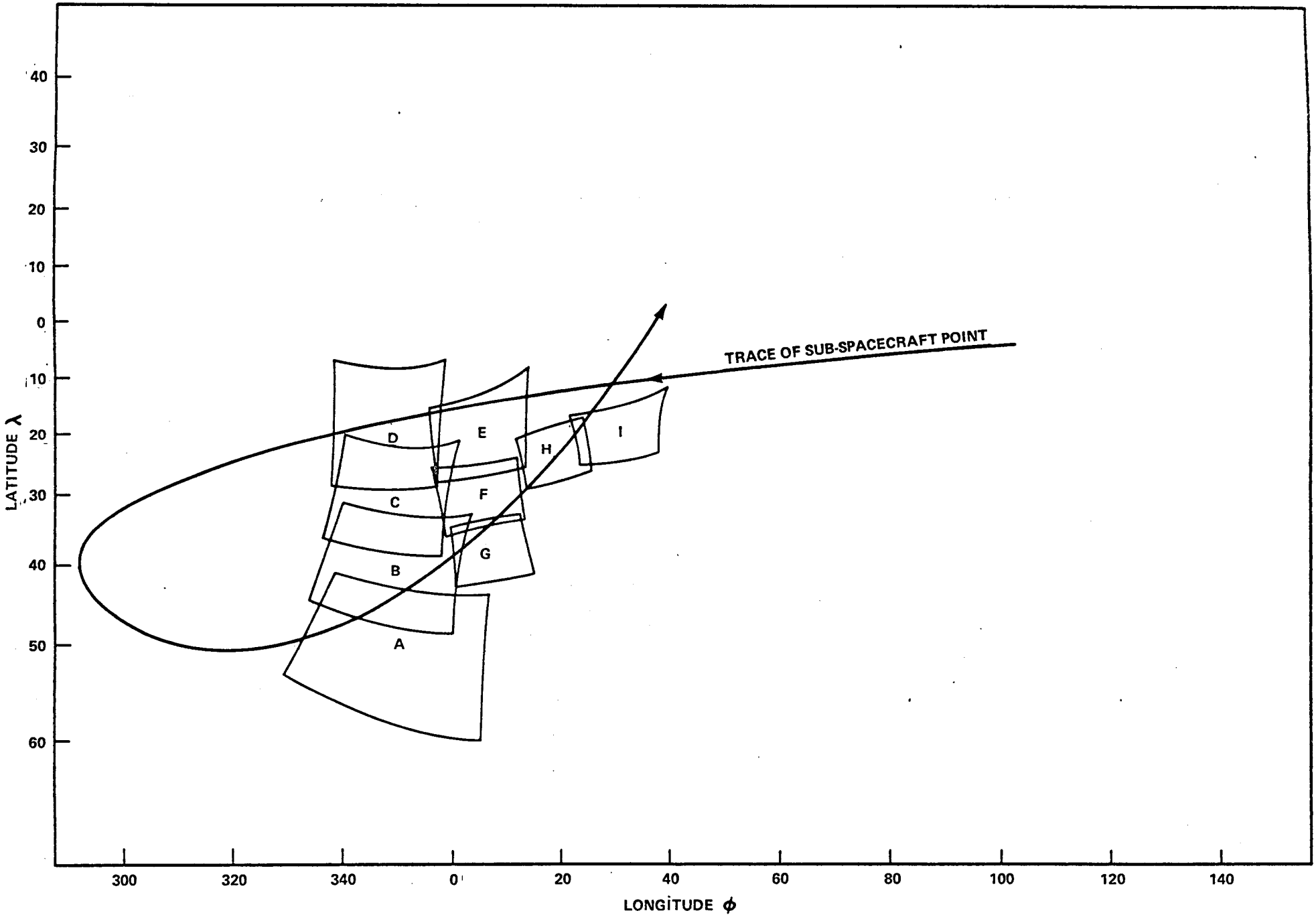

FIGURE 6. VARIABLE SURFACE FEATURES PHOTOGRAPHY SEQUENCE ,REVOLUTION 73, DAY 100

TABLE 1

ORBITAL ELEMENTS:
PERIOD = 32.877 HOURS
INCLINATION = 50°
PSI = 155°
LAUNCH DATE = 5-12-71, ARRIVAL DATE = 11-19-71
PERIAPSIS ALTITUDE = 1600 KM

REVOLUTION NUMBER = 1 TIME FROM INSERTION = 1 DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PICTURE	TIME BEFORE PERIAPSIS (HOURS)	S/C TRUE ANOMALY (DEGREES)	SURFACE INTERCEPT–FIELD OF VIEW CENTER		SLANT RANGE TO INTERCEPT (KM)	ILLUMINATION ANGLE (DEGREES)	VIEW ANGLE (DEGREES)	PHASE ANGLE (DEGREES)	SCAN PLATFORM ANGLES (DEGREES)		TIME FOLLOWING PREVIOUS EXPOSURE (SECONDS)	SCAN RATE A ONLY (DEG/SEC)	SCAN RATE AB PAIR (DEG/SEC)	SCAN RATE AA PAIR (DEG/SEC)
			LAT. (DEGREES)	LONG. (DEGREES)					CLOCK	CONE				
A	1.097	260	−20	350	7625	27.2	40.9	39.7	169.8	140.3				
B	1.071	261	−35	350	7030	28.2	21.5	34.5	166.8	145.6	95	0.15	0.62	*
C	1.020	263	−52	350	6600	36.9	10.9	27.9	162.5	153.0	182	0.08	0.12	0.20
D	0.973	265	−50	15	6310	28.0	12.6	31.3	154.8	148.7	171	0.09	0.14	0.25
E	0.866	270	−35	15	5780	13.0	24.7	37.4	171.3	142.6	386	0.07	0.07	0.09
F	0.808	273	−20	15	5930	2.0	46.7	44.7	179.2	135.3	207	0.09	0.12	0.18
G	0.691	280	−20	30	5245	15.8	49.5	45.5	179.8	134.5	423	0.003	0.004	0.005
H	0.618	285	−35	30	4245	20.3	24.9	38.7	193.1	141.3	261	0.09	0.11	0.15
I	0.506	294	−45	30	3430	28.0	12.5	38.7	224.9	141.3	404	0.09	0.10	0.11

*TIME INTERVAL BETWEEN EXPOSURES LESS THAN 123 SEC

TABLE 2

ORBITAL ELEMENTS:
PERIOD = 32.877 HOURS
INCLINATION = 50°
PSI = 155°
LAUNCH DATE = 5-12-71, ARRIVAL DATE = 11-19-71
PERIAPSIS ALTITUDE = 1600 KM

REVOLUTION NUMBER = 19 **TIME FROM INSERTION = 26 DAYS**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PICTURE	TIME BEFORE PERIAPSIS (HOURS)	S/C TRUE ANOMALY (DEGREES)	SURFACE INTERCEPT–FIELD OF VIEW CENTER		SLANT RANGE TO INTERCEPT (KM)	ILLUMINATION ANGLE (DEGREES)	VIEW ANGLE (DEGREES)	PHASE ANGLE (DEGREES)	SCAN PLATFORM ANGLES (DEGREES)		TIME FOLLOWING PREVIOUS EXPOSURE (SECONDS)	SCAN RATE A ONLY (DEG/SEC)	SCAN RATE AB PAIR (DEG/SEC)	SCAN RATE AA PAIR (DEG/SEC)
			LAT. (DEGREES)	LONG. (DEGREES)					CLOCK	CONE				
A	1.097	260	–20	350	7625	30.2	41.1	50.9	151.6	129.1				
B	0.996	264	–35	350	6560	31.5	21.6	44.5	152.0	135.5	364	0.02	0.02	0.03
C	0.846	271	–52	350	5490	39.9	8.73	32.3	156.5	147.7	541	0.03	0.04	0.04
D	0.808	273	–50	15	5300	31.2	15.2	36.9	147.4	143.1	136	0.14	0.26	1.07
E	0.772	275	–35	15	5250	16.3	28.3	44.0	156.9	136.0	129	0.19	0.36	2.87
F	0.722	278	–20	15	5430	1.9	48.8	50.1	165.5	129.9	181	0.11	0.15	0.25
G	0.675	281	–20	30	5270	13.3	53.5	49.9	158.7	130.1	168	0.06	0.08	0.16
H	0.553	290	–35	30	3830	21.4	25.0	37.9	174.2	142.1	440	0.07	0.08	0.09
I	0.412	303	–45	30	2910	30.1	13.0	32.3	227.0	147.7	510	0.12	0.14	0.15

TABLE 3

ORBITAL ELEMENTS:
PERIOD = 32.877 HOURS
INCLINATION = 50°
PSI = 155°
LAUNCH DATE = 5-12-71, ARRIVAL DATE = 11-19-71
PERIAPSIS ALTITUDE = 1600 KM

REVOLUTION NUMBER = 37 **TIME FROM INSERTION = 51 DAYS**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PICTURE	TIME BEFORE PERIAPSIS (HOURS)	S/C TRUE ANOMALY (DEGREES)	SURFACE INTERCEPT–FIELD OF VIEW CENTER		SLANT RANGE TO INTERCEPT (KM)	ILLUMINATION ANGLE (DEGREES)	VIEW ANGLE (DEGREES)	PHASE ANGLE (DEGREES)	SCAN PLATFORM ANGLES (DEGREES)		TIME FOLLOWING PREVIOUS EXPOSURE (SECONDS)	SCAN RATE A ONLY (DEG/SEC)	SCAN RATE AB PAIR (DEG/SEC)	SCAN RATE AA PAIR (DEG/SEC)
			LAT. (DEGREES)	LONG. (DEGREES)					CLOCK	CONE				
A	0.972	265	–20	350	6960	31.0	45.5	61.1	145.5	118.9				
B	0.907	268	–35	350	6045	34.5	24.8	54.7	143.2	125.3	238	0.04	0.06	0.08
C	0.691	280	–52	350	4525	43.4	10.0	34.3	152.4	145.7	778	0.04	0.04	0.05
D	0.646	283	–45	12	4275	30.6	14.3	41.1	146.7	138.9	160	0.10	0.16	0.34
E	0.604	286	–35	12	4140	20.7	24.8	45.4	155.9	134.6	150	0.13	0.20	0.51
F	0.553	290	–20	12	4290	6.5	47.0	52.6	166.0	127.4	185	0.12	0.17	0.28
G	0.506	294	–20	30	4090	15.1	50.7	50.8	154.9	129.2	169	0.10	0.15	0.27
H	0.462	298	–35	30	3280	24.6	23.8	36.1	159.5	143.9	158	0.17	0.26	0.56
I	0.411	303	–45	30	2905	33.2	13.7	20.5	180.4	159.5	182	0.25	0.37	0.62

TABLE 4

ORBITAL ELEMENTS:
PERIOD = 32.877 HOURS
INCLINATION = 50°
PSI = 155°
LAUNCH DATE = 5-12-71, ARRIVAL DATE = 11-19-71
PERIAPSIS ALTITUDE = 1600 KM

REVOLUTION NUMBER = 55 TIME FROM INSERTION = 75 DAYS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PICTURE	TIME BEFORE PERIAPSIS (HOURS)	S/C TRUE ANOMALY (DEGREES)	SURFACE INTERCEPT–FIELD OF VIEW CENTER		SLANT RANGE TO INTERCEPT (KM)	ILLUMINATION ANGLE (DEGREES)	VIEW ANGLE (DEGREES)	PHASE ANGLE (DEGREES)	SCAN PLATFORM ANGLES (DEGREES)		TIME FOLLOWING PREVIOUS EXPOSURE (SECONDS)	SCAN RATE A ONLY (DEG/SEC)	SCAN RATE AB PAIR (DEG/SEC)	SCAN RATE AA PAIR (DEG/SEC)
			LAT. (DEGREES)	LONG. (DEGREES)					CLOCK	CONE				
A	0.691	280	–20	350	5185	29.3	47.6	62.8	149.7	117.2				
B	0.632	284	–35	350	4285	35.6	23.0	51.9	148.8	128.1	211	0.07	0.09	0.13
C	0.591	287	–47	350	3900	43.6	5.8	40.0	145.8	140.0	146	0.14	0.23	0.64
D	0.553	290	–40	10	3765	30.6	20.0	47.6	138.7	132.5	137	0.15	0.26	1.04
E	0.517	293	–30	8	3685	21.4	29.8	51.1	149.1	128.9	108	0.16	0.30	2.38
F	0.484	296	–20	10	3795	11.4	44.7	55.6	154.5	124.4	121	0.13	0.25	*
G	0.431	301	–20	20	3480	11.2	44.5	52.5	150.7	127.5	191	0.05	0.07	0.11
H	0.402	304	–20	30	3410	18.1	48.5	50.0	143.0	130.0	104	0.15	0.45	*

*TIME INTERVAL BETWEEN EXPOSURES LESS THAN 123 SEC

TABLE 5

ORBITAL ELEMENTS:
PERIOD = 32.877 HOURS
INCLINATION = 50°
PSI = 155°
LAUNCH DATE = 5-12-71, ARRIVAL DATE = 11-19-71
PERIAPSIS ALTITUDE = 1600 KM

REVOLUTION NUMBER = 73 TIME FROM INSERTION = 100 DAYS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PICTURE	TIME BEFORE PERIAPSIS (HOURS)	S/C TRUE ANOMALY (DEGREES)	SURFACE INTERCEPT–FIELD OF VIEW CENTER		SLANT RANGE TO INTERCEPT (KM)	ILLUMINATION ANGLE (DEGREES)	VIEW ANGLE (DEGREES)	PHASE ANGLE (DEGREES)	SCAN PLATFORM ANGLES (DEGREES)		TIME FOLLOWING PREVIOUS EXPOSURE (SECONDS)	SCAN RATE A ONLY (DEG/SEC)	SCAN RATE AB PAIR (DEG/SEC)	SCAN RATE AA PAIR (DEG/SEC)
			LAT. (DEGREES)	LONG. (DEGREES)					CLOCK	CONE				
A	0.691	280	–50	350	4590	51.0	18.2	62.8	122.0	117.2				
B	0.646	283	–40	350	4340	43.0	20.8	63.8	129.5	116.2	160	0.07	0.11	0.23
C	0.604	286	–30	350	4265	35.8	32.3	65.2	137.2	114.8	150	0.08	0.14	0.34
D	0.553	290	–20	350	4250	29.7	45.6	65.7	145.2	114.4	185	0.06	0.08	0.14
E	0.421	302	–20	6	3370	17.1	41.4	58.2	143.4	121.8	474	0.02	0.03	0.03
F	0.392	305	–30	6	2850	26.1	19.2	45.2	141.8	134.8	104	0.23	0.67	*
G	0.347	310	–38	8	2560	33.4	9.3	27.5	139.9	152.5	163	0.16	0.24	0.50
H	0.305	315	–23	19	2520	19.0	28.6	40.6	138.7	139.4	152	0.13	0.21	0.50
I	0.273	319	–20	30	2610	22.9	42.7	40.1	126.2	139.9	115	0.18	0.40	*

*TIME INTERVAL BETWEEN EXPOSURES LESS THAN 123 SEC

TABLE 6

VARIATIONS IN ILLUMINATION, EMISSION & PHASE ANGLES FOR SELECTED POINTS OVER THE FIRST 100 DAYS

11/19/71 ARRIVAL AT MARS

$\phi \equiv$ LONGITUDE OF POINT OF INTEREST
$\lambda \equiv$ LATITUDE

SELECTED POINTS ARE CENTERS OF FOOTPRINTS FOR VARIABLE SURFACE FEATURES STUDY ACQUIRED ON REVOLUTION 1 OF THE B MISSION

ϕ, λ		350, –20	350, –35	350, –52	15, –50	15, –35	15, –20	30, –20	30, –35	30, –45
ILLUMINATION ANGLE	I_1	27.2	28.2	36.9	28.0	13.0	2.0	15.8	20.3	28.0
	I_{26}	30.2	31.5	39.9	31.2	16.3	1.9	13.3	21.4	30.1
	I_{51}	30.9	35.5	43.4	35.3	20.3	5.4	15.0	24.6	33.2
	I_{75}	29.3	35.6	47.5	–	25.1	10.1	18.1	–	–
	I_{100}	29.7	39.1	52.5	–	30.0	22.8	22.8	–	–
EMISSION ANGLE	E_1	40.9	21.5	10.9	12.6	24.7	46.7	49.5	24.9	12.5
	E_{26}	41.1	21.6	8.7	15.2	28.3	48.8	53.5	25.0	13.0
	E_{51}	45.5	24.8	10.0	15.9	26.5	47.4	50.7	23.8	13.9
	E_{75}	47.6	23.0	10.9	–	31.3	46.6	48.5	–	–
	E_{100}	45.6	24.5	18.6	–	25.2	47.6	44.1	–	–
PHASE ANGLE	P_1	39.7	34.5	27.0	31.3	37.4	44.7	45.5	38.7	38.7
	P_{26}	50.9	44.5	32.3	36.9	44.0	50.1	49.9	37.9	32.3
	P_{51}	61.1	54.7	34.3	38.1	45.9	52.8	50.8	36.1	20.5
	P_{75}	62.8	51.9	36.6	–	52.5	56.3	50.0	–	–
	P_{100}	65.7	66.4	61.8	–	34.1	60.3	40.1	–	–

SUBSCRIPT DENOTES TIME IN ORBIT IN DAYS
ALL ANGLES IN DEGREES
ILLUMINATION ANGLE = 0° WHEN SUN DIRECTION IS VERTICAL

BELLCOMM, INC.

Subject: Mars Mariner '71 Variable Surface Features Television Experiment: Preliminary Footprints for Selected Revolutions of the B Mission Orbit

From: G. A. Briggs

Distribution List

NASA Headquarters

W. O. Armstrong/MTX
C. J. Donlan/MD-T
E. W. Glahn/SL
E. W. Hall/MTG
D. P. Hearth/SL
H. F. Hipsher/SL
W. Jakobowski/SL
T. A. Keegan/MA
R. L. Lohman/MTY
D. R. Lord/MTD
M. A. Mitz/SL
D. G. Rea/SL
L. Roberts/OART-M (2)
A. D. Schnyer/MTV
M. G. Waugh/MTP
J. W. Wild/MTE

Goddard Space Flight Center

R. Hanel

Jet Propulsion Laboratory

R. Becker ✓
W. Bollman ✓
A. Conrad
M. Devirian
J. Freeman
H. Friedman 186-118
S. Gunter ✓ 183-801
N. Haynes 169-327
C. Hepburn
A. Kliore
D. Norris 168-222
W. O'Neill ~~168-222~~ 126-244
E. Pounder 169-327
J. Randolph ✓ 169-214
O. Raper 183-601
M. Sander 168-227
D. Schneiderman ~~168-227~~ 169-327
L. Simmons 165-222
R. Steinbacher 169-335
T. Thorpe ✓

Langley Research Center

J. S. Martin, Jr.
G. Soffen
A. T. Young

University of Arizona ✓

W. Hartman

California Institute of Technology

N. Horowitz ✓
R. Leighton
B. Murray ✓
G. Neugebauer ✓
R. Sharp ✓

University of Colorado

C. Barth ✓

Cornell University

J. Pollack ✓
C. Sagan ✓

Massachusetts Institute of Technology

T. McCord ✓
I. Shapiro ✓

New Mexico State University

B. Smith ✓

Rand Corporation

M. Davies ✓

Stanford University

J. Lederberg
E. Levinthal

BELLCOMM, INC.

Distribution List (Continued)

University of Texas

G. de Vaucouleurs

United States Geological Survey

R. Batson
W. Borgeson
M. Carr
H. Masursky
J. McCauley
D. Milton
R. Wildey
D. Wilhelms

University of Washington

C. Leovy

Bellcomm, Inc.

G. M. Anderson
D. J. Belz
A. P. Boysen, Jr.
D. A. Corey
C. L. Davis
D. A. DeGraaf
F. El-Baz
D. R. Hagner
N. W. Hinners
W. W. Hough
B. T. Howard
D. B. James
J. Kranton
H. S. London
J. Z. Menard
G. T. Orrok
I. M. Ross
P. F. Sennewald
W. B. Thompson
J. W. Timko
R. L. Wagner
J. E. Waldo
M. P. Wilson
All Members Division 101
Department 1024 File
Central File
Library